

and reviews now cover extraction, purification, structural characterization, and structure-activity relationships as the basis for applications in foods, pharmaceuticals, cosmetics, and biomaterials (Gong et al., 2023; Shu et al., 2026). Processing is not a neutral step: different methods, including nine steaming and nine drying, wine processing, and honey processing, alter polysaccharide structure and biological activity, so product development should be based on targeted process optimization rather than generic primary processing (Zhao et al., 2026). Rapid quality evaluation technologies can support this transition, as near-infrared spectroscopy combined with chemometrics has already been reported for fast quantitation of polysaccharides and saponins in *P. cyrtonema* (Liao et al., 2023).

Processing upgrades should feed directly into diversified product development rather than remain limited to crude medicinal slices. *Polygonatum* is already recognized as a medicinal-and-food homologous resource with low toxicity after proper processing and broad application prospects in functional foods, pharmaceuticals, cosmetics, and preventive health products (Zhao et al., 2018; Hu et al., 2023). Current reviews emphasize that food-sector applications remain underdeveloped relative to medicinal research, even though *P. odoratum* has long been used as vegetables, foods, functional foods, and tea, and *P. sibiricum* and *P. odoratum* are already included in China's Medicinal Food Directory because of their safety profiles (Bi et al., 2023). A practical development route is therefore to expand from traditional rhizome products toward ingredient-based functional foods, whole-food products, eco-friendly carriers, and other bio-based materials built around polysaccharides and other active constituents (Yang et al., 2025).

4.3 Construction of an industrial chain model integrating “understory cultivation-product processing-brand marketing”

The third pathway is to construct an integrated industrial chain linking understory cultivation, processing, and brand marketing. Medicinal plant commercialization tends to fail when production, demand, and downstream quality requirements are disconnected, and value-chain research shows that successful commercialization requires understanding both demand systems and production systems rather than treating cultivation alone as the core problem (Palash et al., 2021). For *Polygonatum*, this means aligning planting mode, varietal selection, processing standards, and product positioning with market demand, a need echoed by recent understory-cultivation policy analysis that calls for stronger market alignment, quality certification, and regulatory frameworks that enable premium pricing (Guo et al., 2026). Certification, traceability, and safety are especially important because they shape buyer decisions and determine whether producers can enter higher-value markets.

An effective chain model also requires organization beyond the farm gate. Integrated value-chain approaches can shorten supply chains, strengthen backward and forward linkages, improve farmer bargaining power, and support certification adoption and premium realization, while intersectoral partnerships can improve the position of small-scale producer organizations (Volenzo and Odiyo, 2020). Evidence from medicinal-plant business studies likewise shows that lack of modern production and business techniques, weak finance, inadequate training and extension, and unstable price and demand constrain the full marketing system, whereas suitable planning across production, processing, and marketing can improve long-run performance (Palash et al., 2021). For *Polygonatum*, brand marketing should therefore be built on origin authenticity, standardized quality, safety certification, and the combined identity of “medicinal, edible, ecological, and wellness-oriented” products rather than on raw-material sales alone (Cheng et al., 2026; Tang et al., 2026).

4.4 Integration of ecological conservation with emerging industries such as forest wellness tourism

The fourth pathway is to integrate ecological conservation with forest wellness tourism and related emerging industries. Understory medicinal-plant cultivation already plays a positive role in the protection and sustainable use of forest resources, biodiversity, and the ecological environment, which makes *Polygonatum* suitable for development models that combine production with ecological services (Cheng et al., 2026). At the same time, wild-resource exploitation without effective domestication and governance can intensify ecological degradation,